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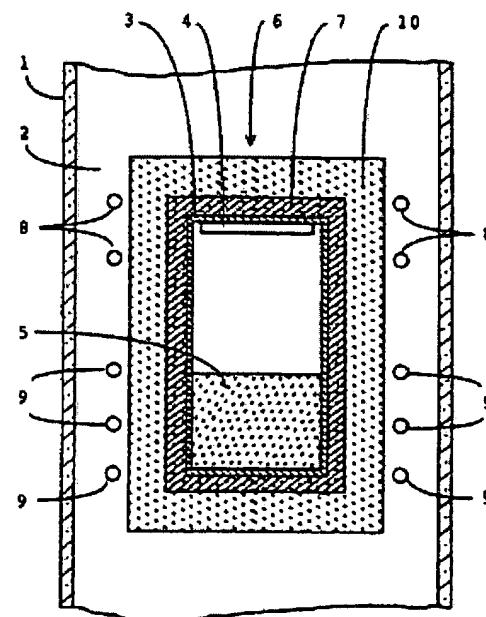
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(54) Title: EPITAXIAL GROWING METHOD FOR
GROWING ALUMINUM NITRIDE AND GROWING
CHAMBER THEREFOR

(57) Abstract: The invention relates to an epitaxial growing method for growing monocrystalline aluminum nitride from a mixture of nitrogen and aluminum vapors, said method comprising the following steps: a substrate (4) and a source of aluminum (5) are placed opposite to each other inside a growing chamber (3); said substrate is heated to a temperature ensuring the growth of monocrystalline aluminum nitride, whereby said temperature is maintained. Inside the growing chamber (3), the pressure of the mixture of nitrogen and aluminum vapors is maintained, whereby said pressure exceeds, by no more than 400 millibars, a lower threshold equal to the pressure generated within a closed space by a stoichiometric mixture of nitrogen and aluminum vapors formed by evaporation of the source material (5). The invention also relates to a growing chamber (3), whereby the material in contact with the source and the aluminum vapors of the surface inside said chamber is a solid solution of tantalum carbide in carbide.



[Continued on next page]

⁷/Translator note: One error in the original translation: The very last word should be "tantalum", not "carbide"

Epitaxial growing method for growing aluminum nitride and growing chamber therefor.

APPLICABILITY

This invention relates to manufacturing of monocrystalline semiconductor materials for the electronics industry and, specifically, to epitaxial growing from vapor phase of aluminum nitride that is a perspective material for producing surface acoustical wave devices and insulating substrates for semiconductor devices capable to operate at high temperatures.

PRIOR ART

Known methods of growing monocrystalline aluminum nitride are based upon precipitation from a vapor phase of aluminum nitride formed on the substrate as a result of a chemical reaction between an aluminum metal-organic compound and ammonia. These methods have the advantage of relatively low temperature (about 1000 °C) requirement for single-crystal growth, however, the achievable growth rate is too low for commercial growing of sizable crystals.

The other group of methods used for growing single crystals of binary compounds, namely silicon carbide, did not yet receive the needed development work in their application for growing aluminum nitride single crystals. These sublimation methods are based on recombination on the substrate of nitrogen and vapors of aluminum produced by evaporation of the polycrystalline aluminum nitride source material. A known feature of aluminum nitride is that its melting point, established only theoretically, is significantly higher than the temperature at which it decomposes into constituent elements. Therefore, the material transfer from the source to the substrate occurs with forming of nitrogen and vapors of aluminum, which then recombine on the substrate. A necessary condition for single-crystal growth is a temperature differential between the substrate and the hotter source. The source is heated either by an induction SHF heater that heats the crucible that, in this case, is made of electrically conductive material, or by a common resistance-type heater.

The main obstacles for growing large single crystals of aluminum nitride by sublimation methods are the low growth rate, even at temperatures near 2,000 °C, and the very aggressive nature of aluminum vapors towards the crucible material at these temperatures. The materials used include tungsten, graphite, and silicon carbide coated graphite.

The closest to the proposed invention is the sublimation method described by C.M. Balkas, et. al. in the article "Growth of bulk AlN and GaN Single Crystals by Sublimation", Materials Research Society Symposium Proceedings Vol. 449, 1997. This paper describes the experiments in growing aluminum nitride single crystals in a graphite chamber with a resistance-type heater. The substrate was placed inside the chamber, axially to the surface of the source, at varying distances, ranging from 1 to 40 mm from the source. Pure graphite was found to be unsuitable as a crucible material because it disintegrated as a result of the graphite reacting with the aluminum vapors to form aluminum carbide (Al_4C_3). The crystal growing was conducted in graphite crucibles coated with silicon carbide (SiC) that allowed carrying out a single process lasting 10-15 hours at temperatures near 2,000 °C. During this time, the SiC coating would disintegrate due to aluminum diffusion through the coating and its reaction with the graphite. Pressed polycrystalline aluminum nitride powder was used as the source to assure stable evaporation rates and silicon carbide was used as the seed crystal on the substrate. The crystal growing was carried out in the 1,950 – 2,250 °C temperature range with nitrogen purging of the chamber at a fixed pressure of 500 Torr (approximately 670 mBar).

Nitrogen injection at such pressure creates a significant excess of nitrogen in the composition of the vapor phase, as compared to the composition that resulted from evaporation of aluminum nitride source. It is shown by calculation that the aluminum nitride vapor pressure generated under the experimental conditions at temperature of 2,250 °C reaches only 200 mBar.

The above paper states that aluminum nitride possesses a feature described as "very high equilibrium vapor pressure of nitrogen at moderate temperatures".

When one talks of "high" equilibrium vapor pressure of one of the elements of a binary compound that is evaporating with decomposition into constituent elements, any specialist in this field knows that what is meant here, is the comparison of equilibrium partial vapor pressures of the elements of this compound in a closed system in a state of thermal equilibrium. As related to aluminum nitride, the above quoted statement means that, in aluminum nitride vapor, the concentration of nitrogen atoms exceeds the concentration of aluminum atoms by a wide margin. In a closed system, this is only possible if the equilibrium vapor pressures are established in such a way that the aluminum atoms pass from the vapor phase into liquid aluminum phase without recombining with nitrogen. Apparently, generating a high background nitrogen pressure in these experiments is dictated by the desire to avoid the danger of forming liquid aluminum phase (droplets) on the growth surface of the single crystal and on the chamber walls during the growing process, thereby avoiding aluminum losses and any associated defects in the crystalline structure.

However, in the presence of a significant excess of nitrogen in the nitrogen - aluminum vapor mix, the diffusion mechanism of material transfer from the source to the substrate slows down and this transfer rate limits the single crystal growth rate.

In the described experiment, the rapid evaporation of the silicon carbide coating of the crucible hindered the growth at 2,250 °C. The growing process lasted 15 hours at the rate of 30 – 50 $\mu\text{m}/\text{hr}$ and was carried out in the 1,950 – 2050 °C range. An estimated growth rate of 0.5 mm/hr was achieved for a short period of time with the source temperature at 2,150 °C, the distance between the substrate and the source – 4 mm, and while maintaining the substrate temperature at not less than 70 °C below the temperature of the source.

Assuring a significant temperature differential between the substrate and the source in the event of their close proximity represents a technical problem. It can be solved by using complicated technical gimmicks and only through unproductive energy consumption, since the substrate must be cooled while it is being heated by the radiation from the source. Note also that, while providing increased growth rate of the aluminum nitride single crystal, increasing the operating temperature of the source with a concurrent increase in substrate temperature also causes increased energy consumption and results in a sharp decrease in service life of the equipment components that operate at these high temperatures.

DISCLOSURES

The task of this invention is the development of a method and a device for growing aluminum nitride single crystals that would provide high single-crystal growth rates without laying high demands upon such process parameters as the operating temperature of the source and distance and temperature difference between the substrate and the source and could be used repeatedly for growing sizable single crystals without the need to replace equipment components; this, in the end, would justify the industrial use of the method.

This task is solved as follows: Within the epitaxial method for growing monocrystalline aluminum nitride from a mixture of nitrogen and vaporized aluminum that includes opposite placement of the substrate and the source of aluminum in the growing chamber and the heating and maintaining the temperature of the source and the substrate to assure, respectively, the presence of aluminum vapor in the mix and the growth of the aluminum nitride monocrystal on the substrate, according to this invention, the pressure of the nitrogen – vaporized aluminum mix in the growing chamber is maintained in the range of 400 mBar from the minimum value, which equals the pressure that would be created in a confined space by a mix of aluminum vapor and nitrogen generated at the source temperature, at an equal concentration of nitrogen and aluminum atoms.

According to this invention, the aluminum nitride single crystal is grown without the use of a high background nitrogen pressure that would create a significant excess concentration of nitrogen atoms as compared to the concentration of aluminum atoms in the composition of the mix.

Under conditions of a significant excess of nitrogen in the mix, the single-crystal growth rate is limited by the diffusion transfer of aluminum atoms from the source to the substrate. Decreasing the nitrogen excess in the mix to a quantitative composition approaching the stoichiometric ratio between nitrogen and aluminum atoms, corresponding to their equal concentrations in the case of aluminum nitride, results in many-fold increases in aluminum nitride single-crystal growth rates.

The growth rate increases due to quantitative changes in the transfer mechanism of aluminum atoms. As the concentrations of nitrogen and aluminum atoms approach their stoichiometric ratio, the diffusion-based transfer process starts to give way to convection-based transfer, expressed as a directional movement of atoms evaporated from the source, towards the colder substrate. As established by the authors, in the case of the nitrogen – aluminum vapor mix, the convection-based transfer phenomenon exhibits itself quite sharply and is accompanied by a significant increase in the material transfer rate from the source to the substrate. This results in an increased single-crystal growth rate that is limited primarily by the transfer rates.

At the operating temperatures of crystal growing, nitrogen is present in the vapor phase as molecules of N_2 , and the partial pressure ratio of nitrogen to aluminum vapor in their stoichiometric mix equals 1:2. As a result, the lower limit of the predetermined pressure range is 1.5 times higher than the partial pressure of aluminum vapor generated by evaporating source material in a confined space.

It is advisable to maintain the pressure of the nitrogen – aluminum vapor mix within the chamber near the lower limit of the predetermined range that corresponds to the stoichiometric ratio of nitrogen and aluminum atoms in the mix, when the aluminum nitride single-crystal growth rate is at its maximum.

One of the possible embodiments of this invention is to utilize aluminum nitride as the source material, to evacuate and seal the growing chamber prior to heating it up, and to carry out the aluminum nitride single-crystal growing process at the lower limit of the predetermined pressure range of the nitrogen – aluminum vapor mix generated in the growing chamber by evaporation of the source material.

The authors have determined that the evaporation and subsequent recombination process of aluminum nitride source vapors in the hermetically sealed growing chamber occurs without forming a liquid aluminum phase. In the sealed chamber, evaporation of the aluminum nitride source creates a stoichiometric mix of nitrogen and aluminum vapor, i.e. the single crystal growth is carried out at a pressure equal to the lower limit of the predetermined pressure range, when the convection-based transfer mechanism is active and it assures the maximum growth rate.

A different embodiment includes the use of aluminum nitride as the source material and the growing chamber, communicably connected to the outside, being placed in a nitrogen atmosphere where the pressure is maintained within the predetermined pressure range for the interior of the growing chamber.

In the case aluminum nitride is used as the source material in a non-sealed growing chamber, maintaining the desired quantitative composition of the mix inside the growing chamber by the use of a background nitrogen pressure from the outside allows achieving single-crystal growth rates near those achieved in a sealed growing chamber. This method utilizes a less expensive option, one that can be re-used for multiple growing processes without sealing the growing chamber.

Yet another embodiment includes the use of metallic aluminum as the source material and the growing chamber, communicably connected to the outside, being placed in a nitrogen atmosphere where the pressure is maintained within the predetermined pressure range for the interior of the growing chamber. In this case the nitrogen for the vapor mix is supplied from the outside of the growing chamber.

In the temperature range below 2,400 °C, the metallic aluminum source provides a higher single crystal growth rate than a source made of aluminum nitride.

This task is also solved with the following: Within the growing chamber for the epitaxial growing of monocrystalline aluminum nitride from a mixture of nitrogen and vaporized aluminum, designed to accommodate internal placement of the source of aluminum and the substrate, with heating and maintaining the temperature of the source and the substrate to assure the growth of the aluminum nitride single crystal on the substrate, according to this invention, the surface of the growing chamber in contact with the source and with aluminum vapors is made of a solid solution of tantalum carbide in tantalum.

The authors have discovered that carbon-doped tantalum (Ta) will withstand the attack of molten aluminum and aluminum vapors up to a temperature of at least 2500 °C. Using this material as the internal lining of the growing chamber allows re-using the growing chamber numerous times, even when using metallic aluminum as the source of aluminum.

SUMMARY DESCRIPTION OF DRAWINGS

Fig. 1 shows the schematic drawing of the aluminum nitride single-crystal growing device;

Fig. 2 shows the Temperature vs. Pressure curves for stoichiometric mixes of nitrogen with aluminum vapor in a confined space for two different aluminum source materials;

Fig. 3 shows a family of curves of aluminum nitride single-crystal growth rates as a function of the nitrogen – aluminum vapor mix pressure for three different temperatures, when using aluminum nitride as the aluminum source material.

EMBODIMENT VERSIONS

Growing of a single crystal of aluminum nitride is carried out in the device shown on Fig. 1. The device is comprised of a body (1) made, for example, of quartz. Its cavity (2) holds the growing chamber (3) made in the shape of a cylinder closed by two end walls. Substrate (4) is attached to one of the end walls of the growing chamber (3) that may be made in the form of a removable cover. Monocrystalline aluminum nitride or silicon carbide, with its crystalline structure closely resembling that of aluminum nitride, is used as substrate (4). Aluminum source (5) is placed opposite substrate (4) in the growing chamber (3). Induction heater (6) comprised of a cylindrical receiver (7) of induction currents, made of electrically conductive graphite, and two, separately powered sections (8) and (9) of SHF coils. Receiver (7) is surrounded by thermal insulator (10), which, for example, may be made of porous graphite. This design of a growing chamber provides the ability to heat the aluminum source (5) to at least 2,500 °C by using section (9) of the heater. Using separate section (8) for heating the substrate (4) allows achieving the predetermined positive temperature differential between the source (5) and the substrate (4).

The growing chamber design is a function of the target dimensions of the growing single crystals. For growing of single crystals with high thickness, up to a few tens of millimeters, the induction heater may be provided with the ability to be moved along the growing chamber, so that the temperature field created by the heater could be shifted in response to the changes in the location of the single-crystal growth surface, thereby maintaining the permanent growing parameters. The induction heater may not contain separate sections (8) and (9) if the growing chamber design is able to provide the required temperature differential between the source (5)

and substrate (4). A resistance-type heater, whose heating element would encircle the aluminum source region, can be used in place of the induction heater.

To increase the single-crystal growth rate, the temperature differential between the source (5) and the substrate (4) should be maintained at a few tens of degrees, while the distance between the source (5) and the substrate (4) should be kept to the minimum for the same purpose. These two requirements contradict each other, since at close proximity of the substrate to the source it is difficult to maintain a significant temperature difference between them due to radiant heating of the substrate (4) by source (5). This contradiction can be overcome by applying special cooling measures to the substrate. This, however, will lead to nonproductive energy losses. As a compromise, if no cooling measures are planned, it is advisable to select a gap between the source and the substrate of 3 – 10 mm for temperature differentials of 10 – 30 °C respectively.

The walls of the growing chamber (3) are made of tantalum and their inside surfaces are doped with carbon. The carbon-doping is carried out as follows. The growing chamber (3) is filled with graphite powder and is slowly heated to 2200 - 2500 °C. The temperature is ramped up at a constant rate for 1 - 3 hours and the growing chamber (3) is then held at the maximum temperature for another 1 - 3 hours. As a result of this process, the interior walls of the growing chamber (3) become a solid solution with a decreasing concentration of tantalum carbide in tantalum. The resulting refractory material, as shown by the authors, resists attack by aluminum up to temperatures at least 2500 °C, thereby providing the ability to carry out multiple aluminum nitride single-crystal growing cycles in growing chambers of this type without replacing or repairing any of its components. It is important to note that the inside walls of the growing chamber (3) treated in the described manner practically do not absorb any aluminum and allow using metallic aluminum as the aluminum source.

In the version where the single crystal is grown from a vaporized aluminum nitride source in a hermetically sealed growing chamber, the process is carried out as follows. To purge the cavity (2) of any ambient gases before heating, it is flushed with pure nitrogen while holding the growing chamber (3) open. The nitrogen is then pumped out of cavity (2) and the growing chamber (3) is hermetically sealed by, for example, vacuum welding. Evacuation and sealing of the growing chamber (3) can also be performed before placing it inside cavity (2). The growing chamber (3) is evacuated to a residual nitrogen pressure that is negligible as compared to the specified deviation range from the pressure of the stoichiometric mix. In practice, a residual nitrogen pressure of a few mBar will suffice.

The source (5), a pressed pellet of polycrystalline aluminum nitride powder, and the substrate (4) are heated using heater (6) to operating temperatures required to carry out the growing process. The recommended operating temperatures for growing aluminum nitride are in the 2000 – 2500 °C range.

As the source (5) is heated, the initial pressure inside the growing chamber (3) caused by the nitrogen residue after evacuation starts increasing as the material of the source (5) starts evaporating. The aluminum nitride evaporates from the source (5) stoichiometrically, i.e. as the AlN molecule is decomposed, both elements enter the vapor phase. No liquid aluminum phase is generated. And, if we neglect the small initial nitrogen content, the concentrations of nitrogen and aluminum atoms inside the growing chamber (3) are equal, i.e. the same number of nitrogen atoms and aluminum atoms are present in a unit of volume.

Therefore, in a hermetically sealed growing chamber (3), the aluminum nitride single-crystal growing process occurs at the lower limit of the pressure range that is defined by a Claim in this invention for the nitrogen – aluminum vapor mix and is the pressure that corresponds to the stoichiometric concentration ratio of nitrogen and aluminum in the mix.

When the composition of the nitrogen – aluminum vapor mix is stoichiometric, the material is transferred from the source (5) to the substrate (4) by convection, which is a

directional movement of aluminum atoms and nitrogen molecules from the source (5) towards the substrate (4), therefore much faster than diffusion-based transfer.

With diffusion-based transfer, the single-crystal growth rate is limited by the transfer rate of the source (5) material to substrate (4), which is inversely proportional to the distance between them. To increase the growth rates, this distance must be kept to the minimum. With a purely convection-based transfer, under conditions of a precise stoichiometric concentration ratio between the atoms of nitrogen and aluminum, the growth rate increases with increasing pressure of the stoichiometric mix. This pressure is a function of the source (5) material evaporation rate. The evaporation rate is practically independent of the distance between the source (5) and substrate (4). As a result, changing the distance between the source (5) and the substrate (4) within the limits not exceeding the lateral dimensions of the substrate (4), will not affect the growth rate. This, in turn, provides us with the ability to work with higher temperature differentials between the source (5) and the substrate (4), resulting in increased evaporation rates of the source (5) material and, accordingly, an additional increase in the single-crystal growth rate.

In the hermetically sealed growing chamber (3) the intrinsic vapors of the aluminum nitride source (5) form a mix with a stoichiometric concentration ratio of nitrogen and aluminum atoms. This assures the maximum growth rate of the single crystal, as compared to the rate that can be achieved under the same conditions but with excess nitrogen in the mix.

Aluminum nitride vapor pressure, as a function of temperature of source (5) inside a hermetically sealed growing chamber (3), as derived by numerical methods, is presented in Figure 2, Curve A. For example, according to Curve A, at the temperature of 2,200 °C, the calculated vapor pressure is approximately 100 mBar.

The version of crystal growing without sealing the growing chamber (3) is more suitable for carrying out successive growing cycles for aluminum nitride single crystals, permitting quick removal of the produced single crystal.

When using polycrystalline aluminum nitride as the aluminum source (5) material, the growing of the single crystal is carried out as follows.

Before starting the heat-up, the source (5), substrate (4), and growing chamber (3) are prepared exactly as in the previous version.

When growing single crystals without hermetic sealing of the growing chamber (3), the leakage of source (5) vapors must be prevented. For this purpose, a balancing nitrogen pressure, equal to or above the pressure that would be generated by the intrinsic vapors of aluminum nitride source (5) in a confined space, is applied through the gaps between the components of the cavity or through specially made channels (not shown), to cavity (2) that is communicably connected with the growing chamber (3). The nitrogen pressure is controlled by measurements in the cold section of cavity (2), away from the growing chamber (3). A wide range of instruments, based on various measurement principles, are available to measure the pressures utilized in this method, all within the 1 – 2000 mBar range: thermocouple-based, membrane-type, and others. For example, the membrane-type pressure-and-vacuum gauge MEMBRANOVAC DM-12, made by LEYBOLD INFICON Inc. could be used for these measurements.

Selecting a nitrogen pressure level for cavity (2) is the key to achieving high growth rates of aluminum nitride single crystals at moderate working temperatures of source (5) and moderate temperature differentials between source (5) and substrate (4). To achieve the maximum growth rate in the steady-state operating temperature mode, the nitrogen pressure in cavity (2) must equal the pressure of aluminum nitride vapors in confined space, for example, in the hermetically sealed growing chamber (3), having a stoichiometric concentration ratio of the nitrogen and aluminum atoms.

The pressure in cavity (2) corresponding to the maximum growth rate of the single crystal at a given operating temperature of source (5) can be found on Figure 2, Curve A,—showing

pressure in mBars as a function of temperature in degrees Celsius. Curve A shows the calculated value of pressure generated in a confined space by a stoichiometric mix of aluminum vapors, formed by evaporation of source (5) material, and nitrogen, for the case when aluminum nitride is used as the source (5) material.

Before starting the heat-up, an initial minimal nitrogen pressure, for example a few mBar, is established in cavity (2) and, accordingly, in the growing chamber (3) communicably connected with the cavity. As source (5) is heated, the nitrogen pressure in cavity (2) is being raised in accordance with the calculated increase of the vapor pressure of source (5), finding the continuous pressure increase rate from Curve A, Figure 2. Therefore, at any moment during the heating-up process, the pressure in cavity (2) exceeds the calculated vapor pressure of aluminum nitride in the growing chamber (3) by the value of the initial pressure established in cavity (2). This procedure for reaching the operating mode of crystal growth is the best in the sense that it aids in avoiding any aluminum vapor losses at this stage and prevents their potential contact with unprotected components of the device which could occur if aluminum vapors escaped beyond the internal cavity of the growing chamber (3). The latter could occur if the nitrogen pressure corresponding to the operating mode was created in cavity (2) before starting the heating-up. In such case, nitrogen would enter into the growing chamber (3) from cavity (2) before the heating-up, then, during heating-up, due to forming aluminum nitride vapors, the pressure in the growing chamber (3) would increase above the external pressure and some of the nitrogen – aluminum vapor mix would be forced out into cavity (2), while an excess of nitrogen would remain within the growing chamber (3), impeding the single-crystal growth.

Fig. 3 shows a family of curves corresponding to three different temperatures of aluminum nitride single-crystal growth rates (in mm per hour) as a function of nitrogen pressure (in mBars) in cavity (2), equal to the total pressure of nitrogen – aluminum vapor mix within the growing chamber (3). The graphs correspond to a 70 °C temperature differential between the source (5) made of aluminum nitride and the substrate (4) and to a 4 mm distance between the source (5) and the substrate (4). These graphs can be used to determine the allowable range of deviation for nitrogen and aluminum atom concentrations from their stoichiometric ratio in the mix that would not cause a significant decrease in the single crystal growth rate and, in particular, to select an initial nitrogen pressure value for cavity (2).

When attempting the first crystal growing in a particular growing chamber (3), while heating up source (5), the nitrogen pressure can be raised in cavity (2) faster than determined from Curve A, Fig. 2, resulting in a higher nitrogen excess in the mix within the growing chamber during the growth stage and a corresponding decrease in growth rate. Based upon the results of growth tests, the rate of pressure increase and, correspondingly, the final nitrogen pressure in cavity (2) can be corrected in the future thereby compensating for errors in calculations and in temperature measurements.

When using metallic aluminum as the material of the aluminum source (5), the growing of aluminum nitride single crystals is carried out in growing chamber (3) communicably connected with cavity (2) similar to the previous version. The specific feature of this version is the absence of nitrogen in the source material. The nitrogen – aluminum vapor mix is formed in growing chamber (3) by utilizing nitrogen that is entering from cavity (2).

While heating up source (5), the nitrogen pressure in cavity (2) is adjusted according to the graph shown as Curve B, Fig. 2. Curve B shows the calculated value of the pressure generated in a confined space by a stoichiometric mix of aluminum vapor formed by the evaporation of source (5) and nitrogen for the case where the material of source (5) is metallic aluminum.

Curve B, corresponding to metallic aluminum, shows a higher total pressure of the stoichiometric mix of nitrogen and aluminum vapor within growing chamber (3) at moderate temperatures of source (5) as compared to Curve A that corresponds to aluminum nitride. Given

that the aluminum nitride single-crystal growth rate increases with an increasing pressure of the stoichiometric mix of nitrogen and aluminum vapor, using metallic aluminum as the material of aluminum source (5) assures a higher growth rate at the lower end of the operating temperature range for source (5), i.e. below 2,400 °C, which is preferred for practical applications. Using metallic aluminum as the material of source (5) allows monitoring the single crystal growth rate during the growing process by measuring the consumption rate of nitrogen required to maintain a constant pressure in cavity (2). This provides the ability to optimize the processing parameters directly during the growing process.

The proposed invention is not limited to the described examples of embodiment and allows for modifications that may be obvious to specialists in the field, within the framework of this invention, as defined by the Claims.

CLAIMS

Epitaxial growing method for growing monocrystalline aluminum nitride from a nitrogen – aluminum vapor mix, said method comprising the following: Placing substrate (4) and aluminum source (5) opposite each other within the growing chamber (3); said source (5) and substrate (4) being heated to an operating temperature and this temperature being maintained ensuring, respectively, formation of aluminum vapors in the mix and the growth of monocrystalline aluminum nitride, characterized in that the pressure of the nitrogen – aluminum vapor mix in the growing chamber (3) is maintained within 400 mBar from the lowest value, that being equal to the pressure that would be generated by aluminum vapors and nitrogen forming in a confined space, at equal concentrations of nitrogen and aluminum atoms.

Epitaxial growing method for growing monocrystalline aluminum nitride from a nitrogen – aluminum vapor mix, said method comprising the following: Placing substrate (4) and aluminum source (5) opposite each other within the growing chamber (3); said source (5) and substrate (4) being heated to an operating temperature and this temperature being maintained ensuring, respectively, formation of aluminum vapors in the mix and the growth of monocrystalline aluminum nitride, characterized in that the pressure of the nitrogen – aluminum vapor mix in the growing chamber (3) is maintained within 400 mBar from the lowest value, that being equal to the pressure that is generated by aluminum vapors and nitrogen forming in a confined space at the temperature of the source (5), having equal concentrations of nitrogen and aluminum atoms.

2. A method per Claim 1, wherein the pressure of the nitrogen – aluminum vapor mix in the growing chamber is maintained near the lower limit of the predetermined range.

3. A method per Claim 1, wherein aluminum nitride is used as the material of the aluminum source (5), the growing chamber (3) is evacuated and hermetically sealed prior to starting the heating-up, and the aluminum nitride single crystal growing process is carried out at the lower limit of the predetermined pressure range for the nitrogen – aluminum vapor mix being formed in the growing chamber (3) by evaporation of the source material.

4. A method per Claim 1, wherein aluminum nitride is used as the material of the aluminum source (5), the growing chamber (3) is communicably connected to the outside and is placed into a nitrogen atmosphere with pressure thereof being maintained within a predetermined pressure range;

5. A method per Claim 1, wherein metallic aluminum is used as the material of the aluminum source (5), the growing chamber (3) is communicably connected to the outside and is placed into a nitrogen atmosphere with pressure thereof being maintained within a predetermined pressure range;

6. Growing chamber (3) for the epitaxial growing of monocrystalline aluminum nitride from a nitrogen - aluminum vapor mix, designed to accommodate internal placement of source (5) of aluminum and substrate (4), with heating and maintaining the temperature of source (5) and substrate (4) to assure the growth of the aluminum nitride single crystal on substrate (4), wherein the surface of the growing chamber in contact with the source and with aluminum vapors is made of a solid solution of tantalum carbide in tantalum.

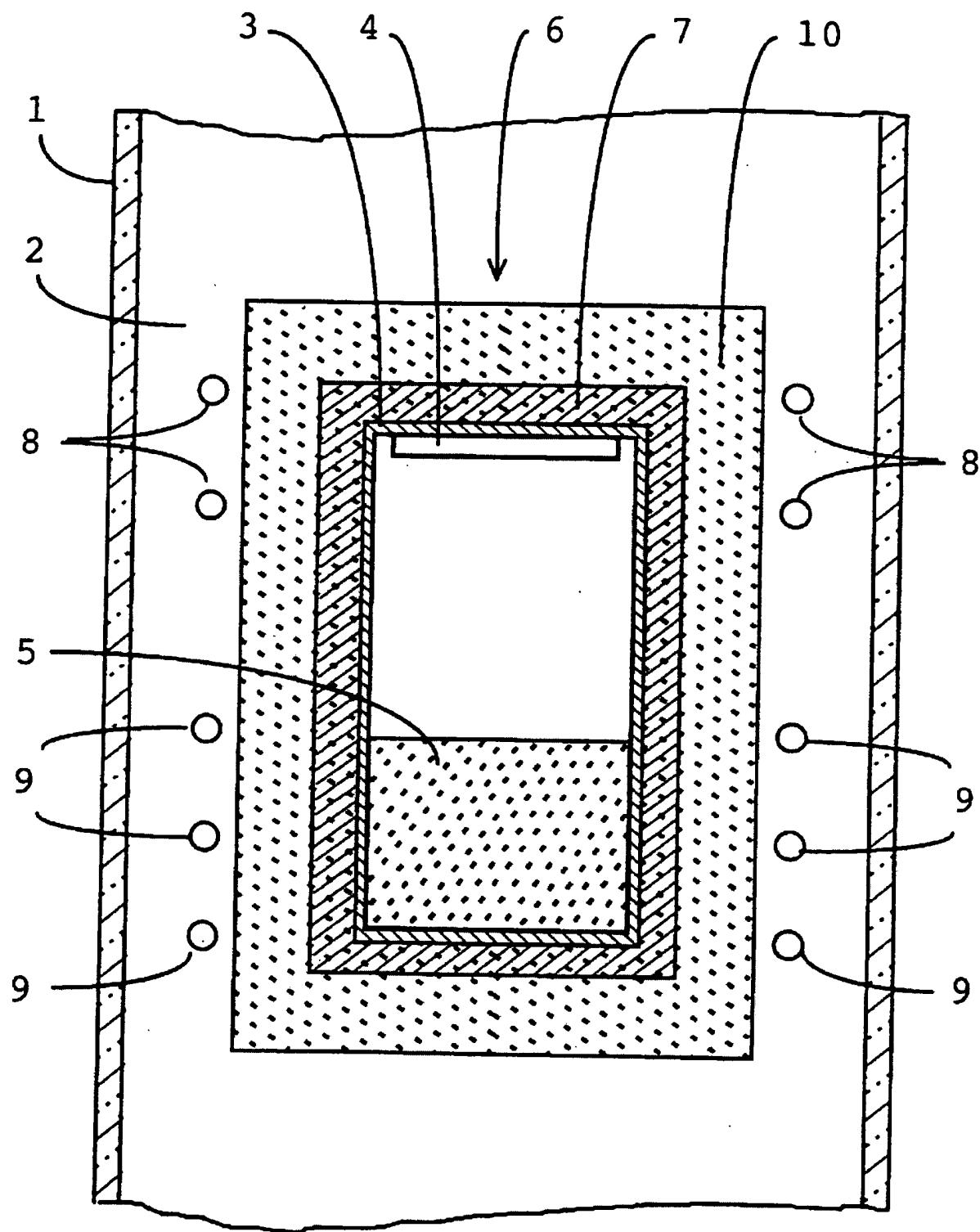


Fig. 1

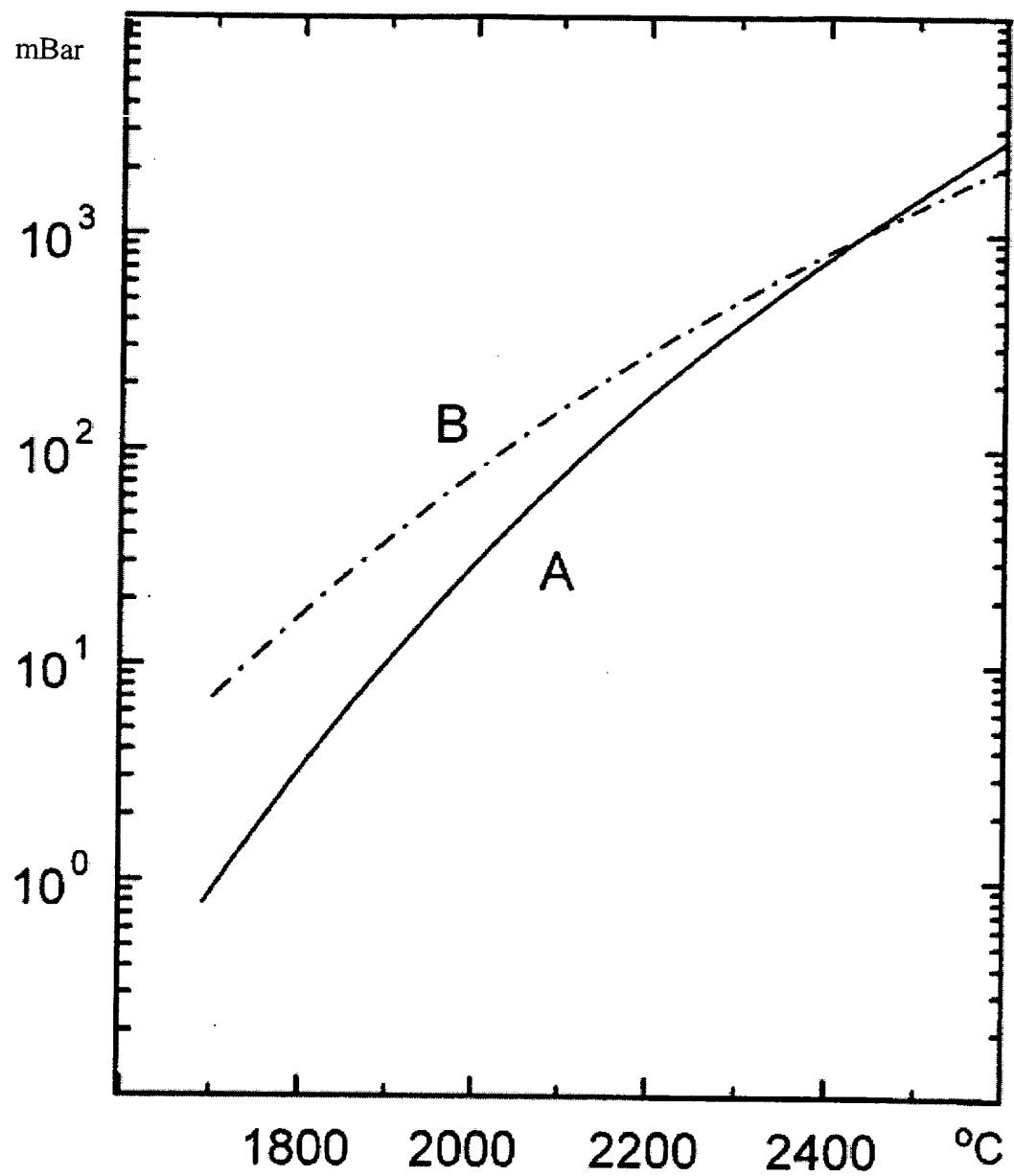


Fig. 2

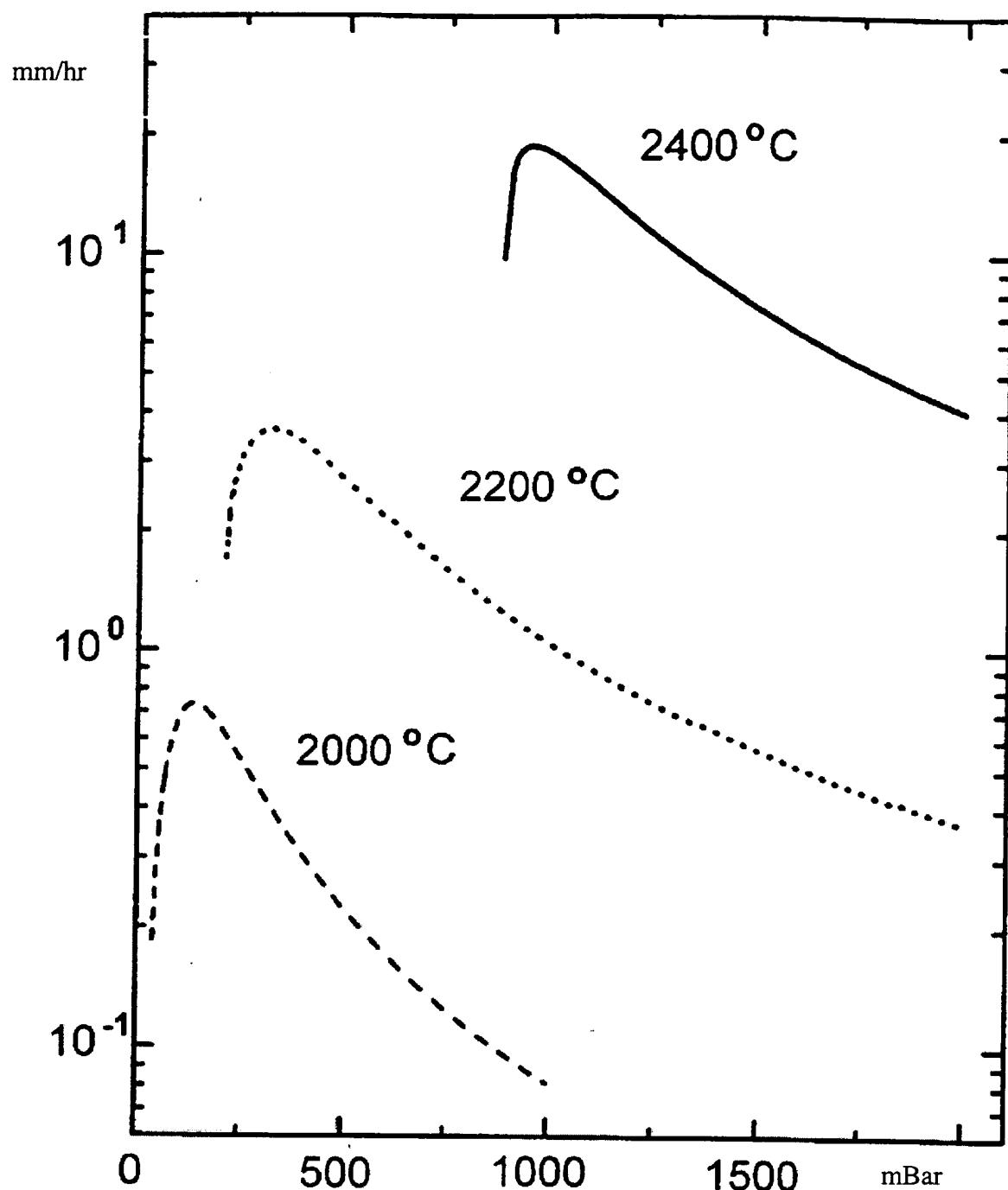


Fig. 3

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